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Stomach Contents and Organ Weights of Some Bluefin Tuna, *Thunnus thynnus* (Linnaeus), near Bimini, Bahamas[1]

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THIS paper records some observations on the kinds and amounts of foods taken from the stomachs of bluefin tuna, together with measurements of the relative weights of some of the viscera of those tuna. In addition, observations were made on the state of development of the gonads and whether or not they appeared to be spent.

Stomach Contents

Although the bluefin tuna is highly prized as a sport fish in the western North Atlantic Ocean, as attested by the many tuna tournaments held in the Bahamas and along the eastern coast of the United States, there are few published records of the different foods eaten by this species. The account in which the greatest number of stomachs was examined is that of Crane (1936) who listed eight separate organisms taken from 34 stomachs. Of those stomachs, five were empty, and of the 29 that remained, 26 contained from 1 to 38 specimens of hake (*Merluccius bilineatus*), four contained seaweed, three contained one or two squids each, two contained large numbers of adult krill (*Meganycitiphanes norvegica*), one contained a single clupeid fish, one contained three clupeid fish of the same kind but different from the one just mentioned, one contained four rosefish (*Sebastes marinus*), and one contained a single specimen of the belonid fish, *Tylosurus marinus*.

In their account of the fishes of the Gulf of Maine, Bigelow & Schroeder (1953) stated that bluefin tuna in that area prey on smaller fishes, especially those of the schooling kinds, that are most abundant locally. They also stated that in the Gulf of Maine the bluefin tuna destroys great numbers of herring and mackerel.

The only published record of foods of the bluefin tuna from the Bahamas is that of deSylva (1956), in which he stated that stomachs of that species taken near Cat Cay, about 12 miles south of Bimini, contained freshly digested squids, along with squid beaks and the radulae of bottom-dwelling snails.

The bluefin tuna referred to in this paper were made available by the Bimini Big Game Fishing Club which sponsored the Bimini Tuna Tournament, May 19-23, 1956. All seven tuna taken during the tournament were turned over to me for study purposes as soon as they were brought to the dock and officially weighed in. The weight of the first tuna brought in is not known, the fish having been mutilated by a shark.

As soon as the fish were weighed, their bellies were split open and the gonads were examined. There were two females and five males, and the condition of the ovaries indicated that both females were mature and probably had spawned within a relatively short time before being caught. The testes of all the males contained mature sperm and their condition indicated that those individuals had spawned already or were in spawning condition at the time of capture.

The stomachs were excised and the identifiable food organisms were removed and preserved in 10 percent. formalin and taken to the Lerner Marine Laboratory for identification. The use of those facilities is hereby acknowledged. Also, I am grateful to Donald deSylva and Gilbert Voss of the University of Miami Marine Laboratory for assistance in identifying the food organisms.

A total of 661 organisms, referable to seven different species, were taken from the stomachs

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of the seven tuna (Table 1). However, not more than four nor fewer than two kinds of organisms were found in any one stomach. The greatest number of organisms found in any one stomach was 275 and the smallest number was four. The most numerous organism was the porcupine fish, *Diodon hystrix*; a total of 560 individuals had been eaten by six of the seven tuna examined. Each porcupine fish was about the size of an English walnut and weighed about 5 grams. They were obviously young of the year, and at that size and age, porcupine fish are known to aggregate at or near the surface. The second most abundant food item was the salp, *Pyrosoma atlantica gigantea,* and four of the tuna had eaten 87 individuals. These salps were four to five inches long and about an inch in diameter. Entire vertebral columns, together with attached crania, of five small, eel-like fish were found in three stomachs. Although the species of fish to which the vertebral columns belonged were not identified, it is believed that they all were of the same species. The columns ranged in length from 6 to 8.5 inches. In addition to the above-mentioned salp, there were three specimens of an obviously different, but unidentified, species of salp in one stomach. Also, one stomach contained the remains of four portunid craps (*Portunus* sp.), and the beak of a small, unidentified octopus. A large plant leaf taken from one stomach was shaped somewhat like a new moon and was about five inches long.

From these data, although they admittedly are meager, several interesting inferences may be drawn. These are (1) the absence of any of the finned fishes such as the herrings, mackerels or mullets, and (2) the presence of large numbers of pelagic porcupine fish in the tuna stomachs.

In her account of the foods of the bluefin tuna near Portland, Maine, Crane (1936) noted that hake from 8 to 13 inches long constituted the principal food item. Similarly, Bigelow & Schroeder (1953) inferred that the principal food of the bluefin tuna was the herring and mackerel or similar species that were locally abundant. Although deSylva (1956) found only the remains of squids and snails in the stomachs of bluefin tuna near Cat Cay, Bahamas, he listed squids, flying fishes, sardines, herring and krill as preferred food items. In the present study, although no such fish were found in the stomachs, the tuna taken during the tournament were caught with baits of finned fishes such as mullet (*Mugil* sp.) that were 12 to 15 inches long. From this information, it is obvious that the bluefin tuna has an extremely varied diet and that the selected foods consist of animals that live at many different depths of the ocean, from the surface to the bottom. This statement is reminiscent of the remarks of Beebe (1936) about the food habits of the blackfin tuna, *Parathunnus atlanticus,* taken near Bermuda.

> "When I examined the stomach of the first of these tunas, I realized that the contents were alien to the shallow waters of Bermuda along

Table 1. Length, Weight and Sex of Seven Bluefin Tuna Caught near Bimini, Bahamas, together with a List of Organisms Taken from Each Stomach

Tuna No.	Total Length (in.)	Weight (lbs.)	Sex	Stomach Contents
1	92	ca. 470	Male	63 *Diodon hystrix* 1 eel-like vertebral column
2	93	470	Female	82 *Diodon hystrix*
3	100	565	Male	242 *Diodon hystrix* 31 *Pyrosoma atlantica gigantea* 1 eel-like vertebral column 1 unidentified plant leaf
4	92	450	Male	29 *Diodon hystrix* 13 *Pyrosoma altantica gigantea*
5	88	361	Male	63 *Diodon hystrix* 12 *Pyrosoma atlantica gigantea* 3 unidentified salps
6	95	370	Male	81 *Diodon hystrix* 31 *Pyrosoma atlantica gigantea* 3 eel-like vertebral columns
7	97	562	Female	4 crabs, *Portunus* sp. 1 beak of unidentified octopus

shore, and yet had nothing in common with the fauna of the deeper, offshore areas. And I will here anticipate another discovery which was emphasized again and again, that these great fish had almost without exception been feeding close to the bottom. Somehow, I had never visualized these swift, pelagic beings as searching over, around and perhaps in the gorges and arches of the eroded limestone. But for that matter I had never thought to find such small, spiny organisms as squilla larvae dominant in their diet."

Beebe listed a total of 1,616 organisms referable to 23 separate species in the stomachs of 18 blackfin tuna taken in September near Bermuda. In the same paper, he listed 22 different kinds of organisms, with a total of 209 individuals, in the stomachs of eight yellowfin tuna, *Neothunnus argentivittata*. However, six of the yellowfin tuna were taken near St. Lucia and one was taken near Bermuda.

In the present study, porcupine fish made up 85 percent. of the total number, and well over 90 percent. of the total weight, of the food organisms recovered from the bluefin tuna stomachs. Thus, for the moment, porcupine fish were the principal item in the diet. This observation falls in line with that of Bigelow & Schroeder (1953) in which locally abundant fishes are eaten most frequently. Although adult porcupine fish are fairly common near Bimini, the occurrence of such large numbers of young in the tuna stomachs indicates that the reproductive capacity must be very great. The six tuna stomachs that contained the 560 young porcupine fish were taken over a four-day period, and the only tuna that did not contain any was taken on the last day of the tournament. Furthermore, all the small porcupine fish were readily identifiable and none were in an advanced state of digestion. Thus, it is apparent that very large numbers of young porcupine fish were available to the tuna over a period of several days and perhaps for several weeks.

Weights of Viscera

So far as I can determine, there is no published record of the percentages of the total body weight of the bluefin tuna made up by the various viscera. In earlier publications (Krumholz, 1956, 1958) I recorded the relative weights of viscera of eight species of freshwater fishes and those of the Atlantic marlins.

When the fish were opened to examine the gonads and to remove the stomachs and their contents, the heart and all abdominal viscera, with the exception of the kidneys, were excised and weighed. The stomach and intestine were separated from each other and from the caecal mass, slit along their greatest lengths, and any debris and mucous material were rinsed away in sea water. Because of the intertwined arrangement of the caeca within the caecal mass, no attempt was made to remove any materials from the lumina, and the entire mass was weighed in the condition in which it was removed from the fish. The chambers of the heart and the openings of the principal afferent and efferent vessels were washed out with sea water to remove any clotted blood. The connective tissue covering of the spleen was removed before weighing. The gall bladder was carefully separated from the liver in each instance so that the bladder would not become ruptured and the contents lost. The liver required little or no cleaning except for the removal of the ligaments of attachment. Each organ was weighed individually to the nearest gram on a triple-beam balance within a half hour after being removed from the fish. All weights are recorded as wet weights, and from these data the percentage of the total body weight made up by each organ was determined for each fish.

The percentage of the total body weights made up by each organ, and all organs combined, for each of the bluefin tuna examined in this study are listed in Table 2. The body weights and sexes of the individual fish are listed in Table 1. The data on the weights of the organs for tuna No. 1 are omitted because that fish was mutilated by a shark while being caught and the total weight of the fish is not known. For tuna No. 2, only the weight of the heart is included, the other viscera having been discarded inadvertently. From the data at hand it is obvious that the gonads, for each sex, contributed more to the total body weight than any other single organ listed. The percentage of the total body weight contributed by the gonads is followed in decreasing order by the stomach, the caecal mass, the liver, the heart, the spleen, the intestine and the gall bladder. The entire gut, consisting of the stomach, caecal mass and intestine, made up 1.50 percent. of the total body weight, and all viscera combined, 3.57 percent.

If the relative weights of the gonads are not considered, a comparison of the percentage of the total body weight contributed by the viscera of the bluefin tuna with those of seven freshwater fishes, the Atlantic marlins and the sailfish (*Istiophorus americanus*), clearly shows that relatively less of the body weight is contributed by the tuna viscera than those of any of the other fishes listed (Table 3). Among the fishes listed in Table 3, the yellow bullhead (*Ictalurus natalis*), the carp (*Cyprinus carpio*), and the red-

TABLE 2. PERCENTAGE OF TOTAL BODY WEIGHT MADE UP BY EACH ORGAN, AND ALL ORGANS COMBINED, FROM SIX BLUEFIN TUNA, TOGETHER WITH THE AVERAGES, TAKEN NEAR BIMINI, BAHAMAS, MAY 19-23, 1956

Tuna No.	2	3	4	5	6	7	Average
Heart	0.393	0.287	0.337	0.320	0.308	0.330	0.329
Stomach		0.763	0.565	0.745	0.866	0.745	0.737
Caecal mass		0.594	0.594	0.739	0.701	0.686	0.663
Intestine		0.085	0.118	0.096	0.111	0.113	0.105
Liver		0.463	0.648	0.602	0.567	0.628	0.582
Gall bladder		0.016	0.028	0.021	0.046	0.044	0.031
Spleen		0.133	0.140	0.138	0.150	0.119	0.136
Subtotal		2.341	2.430	2.661	2.749	2.665	2.569
Testes		0.993	0.913	1.538	0.627		1.003
Ovaries						1.079	1.079
Total		3.277	3.343	4.188	3.349	3.700	3.571

horse (*Moxostoma erythrurum*) have no caeca in the digestive tract. In the carp and the redhorse there is no good, gross line of demarcation between the stomach and the intestine and, consequently, the entire digestive tube was considered as a single entity.

The data in Table 3 indicate that there are several striking differences in the relative weights of the various organs among the different fishes. The viscera of the yellow bullhead contribute relatively more to the total body weight than in any other species. For that measurement, the yellow bullhead is followed in descending order by the carp, the white marlin (*Makaira albida*), the sailfish, the largemouth bass (*Micropterus salmoides*), the blue marlin (*Makaira ampla*), the bluegill (*Lepomis macrochirus*), the redhorse, the white crappie (*Pomoxis annularis*), the black crappie (*P. nigromaculatus*) and the bluefin tuna. Such an arrangement of fishes bears no relationship to taxonomic order and it is difficult to make any clear-cut, general statement on the basis of food habits. All the species listed are primarily carnivorous, with the exception of the carp and the redhorse (both omnivorous) which are second and eighth, respectively, in the series.

Another striking difference is in the relative sizes of the hearts among the 11 species. Here, the bluefin tuna has a larger heart than any of the others and, on a relative basis, only the hearts of the carp and the sailfish even approach it in size. Nearly all the other species have hearts that are less than half the relative size of the tuna's. It is difficult to propose a theory regarding the size of the heart of the tuna. The heart of a 360-pound blue marlin weighed only 265 grams whereas that of a 361-pound bluefin tuna weighed 524 grams, almost exactly twice as much. Both species are rapid, pelagic swimmers, their principal foods are other fishes (see Krumholz & deSylva, 1958, for foods of marlins near Bimini), and there is considerable overlap in their ranges. However, it is said (Brown 1957, vol. 1:217) that the tuna maintains a body temperature considerably higher (6-12° C.) than the surrounding water, and it may be that the large heart plays an important role in maintaining that higher temperature.

Another comparison between the data for the speared fishes listed here and the bluefin tuna shows that the digestive organs of the white marlin and the sailfish weigh relatively more than twice as much as those of the bluefin tuna, whereas those of the blue marlin are relatively more than 75 percent. heavier. It is possible that such differences in the relative weights of the digestive tracts indicate even greater differences in diet than we may now suspect.

The relative sizes of the livers and gall bladders indicate rather marked differences between the marine and freshwater fishes. Such differences are probably linked with digestive processes.

SUMMARY

The stomach contents of seven bluefin tuna taken near Bimini, Bahamas, in May, 1956, consisted of 560 young-of-the-year porcupine fish, 90 salps, the axial skeletons of 5 small, eel-like fish, 4 protunid crabs, the beak of 1 octopus, and a plant leaf. The gonads of all specimens of tuna appeared to be near spawning condition. The weights of viscera indicated that the relative weight of the heart of the bluefin tuna was nearly twice that of the hearts of each of the Atlantic marlins or the sailfish, and even greater than those of each of seven freshwater fishes.

TABLE 3. AVERAGE PERCENTAGE OF TOTAL BODY WEIGHT MADE UP BY DIFFERENT VISCERA OF THE BLUEFIN TUNA COMPARED WITH THE AVERAGES OF SIMILAR ORGANS FROM SEVEN FRESHWATER FISHES, THE ATLANTIC MARLINS AND THE SAILFISH

	Bluefin Tuna	Blue-gill	Black Crappie	White Crappie	Large-mouth Bass	Yellow Bull-head	Carp	Red-horse	White Marlin	Blue Marlin	Sail-fish
No. of fish	5	11	11	5	5	3	5	8	42	3	2
Heart	0.33	0.16	0.09	0.14	0.08	0.12	0.24	0.13	0.18	0.16	0.20
Stomach	0.74					2.89			1.20	1.26	1.41
		1.32	1.20	1.24	2.40						
Caeca	0.66								2.20	1.18	1.62
Intestine	0.10	0.55	0.39	0.43	0.45	1.76			0.68	0.21	0.67
Entire gut*	1.50	1.87	1.59	1.67	2.85	4.65	1.25	0.99	4.08	2.65	3.70
Liver	0.58	1.19	1.03	1.17	0.84	2.25	3.65	2.00	1.08	0.71	0.72
Gall bladder	0.03	0.21	0.25	0.18	0.26	0.28	0.55	0.27	0.06	0.06	0.06
Spleen	0.14	0.11	0.10	0.06	0.08	0.05	0.13	0.11	0.11	0.09	0.14
Total	2.58	3.54	3.06	3.22	4.11	7.35	5.82	3.50	5.51	3.67	4.82

* The entire gut in this instance consists of the stomach, caeca and intestine. See text for explanation.

However, the total weight of the abdominal viscera and the heart of the tuna was relatively less than similar weights for any other species considered. Also, the digestive organs of each of the marlins and the sailfish weighed relatively more than twice as much as those of the tuna.

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